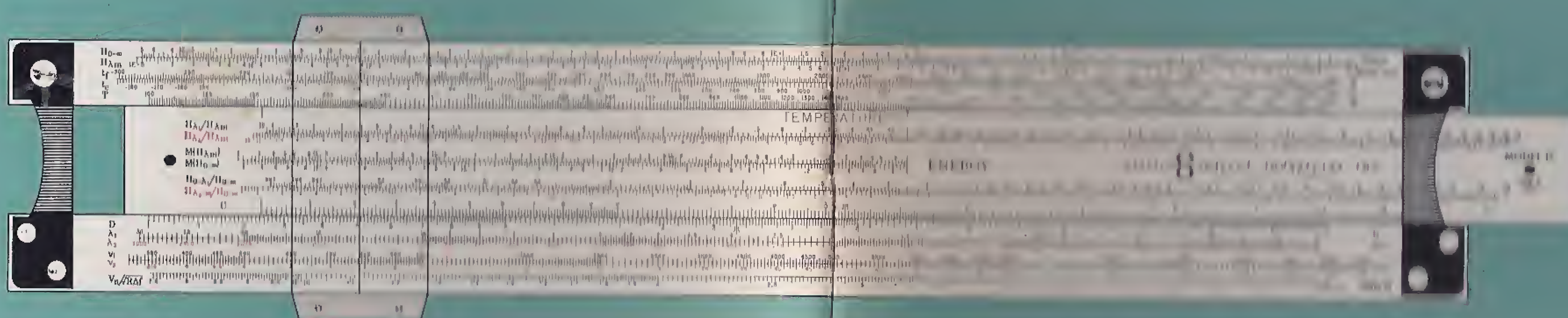
electro optical industries, inc. · *p. o. box 3770* · *santa barbara, california 93105*

electro optical industries inc.

BLACKBODY RADIATION SLIDERULE

manual of instruction and information



ERRATA

Blackbody Radiation Sliderule Manual

Location of Error	Should Read
Page 3, last equation	$\frac{Q_{\lambda 2}}{Q_{\lambda m}} = \frac{\left(\frac{hc}{\lambda_2 kT}\right)^4}{e^{hc/\lambda_2 kT} - 1} \cdot \frac{1}{4.77984082}$
Page 9, No. 1	The word "Piece" should not be capitalized.
Page 9, last equation	$= .42 \left[\int_0^{.75\mu m} H_\lambda d\lambda - \int_0^{.7\mu m} H_\lambda d\lambda \right]$
Page 10, No. 4	$\Delta Q = \int_{\nu = 25,000\ cm^{-1}}^{\nu = 15,000\ cm^{-1}} Q_\lambda d\lambda$ at $3,000^oC$
Page 12, No. 4 second line	. . . 15,000 on the $\underline{\nu_1}$ scale
Page 12, No. 5	$= 2.3 \times 10^{-5}$ W
Page 12, No. 6	$\int_{\lambda a}^{\lambda b} H_\lambda d\lambda = H_\lambda(\lambda_b - \lambda_a) = H_\lambda \Delta\lambda$
Page 14, Operation	. . . smooth movement of the slider. ~~and hinder its free movement.~~
Inside rear cover	**The correct phone number for Electro Optical Industries, Inc. is** **(805) 964-6701**

BLACKBODY RADIATION SLIDERULE

MANUAL OF INSTRUCTION & INFORMATION

First Edition

electro optical industries, inc.

Post Office Box 3770 □ Santa Barbara, California 93105

First Printing

DECEMBER, 1971

LITHOGRAPHED IN THE UNITED STATES OF AMERICA

BY

THE MEAD COMPANY • INGLEWOOD, CALIFORNIA 90304

Copyright © 1971 By Electro Optical Industries, Incorporated

BLACKBODY RADIATION SLIDERULE

Explanation of Scales

Planck's expression for spectral radiant flux density into a surrounding hemisphere in the wavelength interval λ to $\lambda + d\lambda$ is

$$H\lambda = \frac{2\pi hc^2}{\lambda^5} \frac{1}{e^{hc/\lambda kT} - 1} \qquad [W/cm^2\text{-}\mu m]$$

The corresponding expression for spectral radiant photon density is

$$Q\lambda = \frac{2\pi c}{\lambda^4} \frac{1}{e^{hc/\lambda kT} - 1} \qquad [photons/sec\text{-}cm^2\text{-}\mu m]$$

where* $c = 2.997925 \times 10^{10}$ cm/sec
$h = 6.6256 \times 10^{-34}$ Joule-sec
$k = 1.38054 \times 10^{-23}$ Joule/deg-K

t_f, t_c, T

The three temperature scales, t_f, t_c, and T give blackbody temperature in degrees Fahrenheit, Centigrade, and Kelvin, respectively.

λ_1, λ_2

The wavelength scales, λ_1 and λ_2, give wavelength in the intervals

$$.3 \leqslant \lambda_1 \leqslant 30\ \mu m$$
$$30 \leqslant \lambda_2 \leqslant 3000\ \mu m$$

on the ENERGY side of the rule, and

$$.35 \leqslant \lambda_1 \leqslant 40\ \mu m$$
$$40 \leqslant \lambda_2 \leqslant 4000\ \mu m$$

on the PHOTONS side.

*NBS Misc. Publ. 253, Revised May, 1969

ν_1, ν_2

The wavenumber scales give wavenumbers in the intervals

$$320 \leqslant \nu_1 \leqslant 40000 \text{ cm}^{-1}$$
$$32 \leqslant \nu_2 \leqslant 400 \text{ cm}^{-1}$$

on the ENERGY side, and

$$250 \leqslant \nu_1 \leqslant 30000 \text{ cm}^{-1}$$
$$2.5 \leqslant \nu_2 \leqslant 300 \text{ cm}^{-1}$$

on the PHOTONS side.

$H_{0-\infty}, Q_{0-\infty}$

the $H_{0-\infty}$ scale gives the value of

$$H_{0-\infty} = \int_0^\infty H_\lambda \, d\lambda = \frac{2\pi^5 k^4 T^4}{15 h^3 c^2} \qquad [\text{W/cm}^2]$$

the total power radiated by unit area of a blackbody at temperature T.

The analogous photons scale, $Q_{0-\infty}$, gives

$$Q_{0-\infty} = \int_0^\infty Q_\lambda \, d\lambda = \frac{4\pi k^3 (1.202057) T^3}{h^3 c^2} \qquad [\text{photons/sec-cm}^2]$$

the total number of photons emitted by unit area of a blackbody at temperature T in one second.

$H_{\lambda m}, Q_{\lambda m}$

The $H_{\lambda m}$ scale gives the maximum value of the function H_λ at a given value of T,

$$H_{\lambda m} = \frac{2\pi k^5 (21.201436) T^5}{h^4 c^3} \qquad [\text{W/cm}^2\text{-}\mu\text{m}]$$

with

$$Q_{\lambda m} = \frac{2\pi k^4 (4.77984) T^4}{h^4 c^3} \qquad [\text{photons/sec-cm}^2\text{-}\mu\text{m}]$$

the analogous maximum of the function Q_λ.

$H_{\lambda 1}/H_{\lambda m}$, $H_{\lambda 2}/H_{\lambda m}$, $Q_{\lambda 1}/Q_{\lambda m}$, $Q_{\lambda 2}/Q_{\lambda m}$

These scales give the value of the indicated ratios for wavelengths read on either the λ_1 or λ_2 scales. They are

$$\frac{H_{\lambda 1}}{H_{\lambda m}} = \frac{\left(\frac{hc}{\lambda_1 kT}\right)^5}{e^{hc/\lambda_1 kT} - 1} \cdot \frac{1}{21.201436}$$

$$\frac{H_{\lambda 2}}{H_{\lambda m}} = \frac{\left(\frac{hc}{\lambda_2 kT}\right)^5}{e^{hc/\lambda_2 kT} - 1} \cdot \frac{1}{21.201436}$$

$$\frac{Q_{\lambda 1}}{Q_{\lambda m}} = \frac{\left(\frac{hc}{\lambda_1 kT}\right)^4}{e^{hc/\lambda_1 kT} - 1} \cdot \frac{1}{4.77984082}$$

$$\frac{Q_{\lambda 2}}{Q_{\lambda m}} = \frac{\left(\frac{hc}{\lambda_2 kT}\right)^4}{e^{hc/\lambda_2 kT} - 1} \cdot \frac{1}{21.201436}$$

(dimensionless)

$\frac{H_{0-\lambda 1}}{H_{0-\infty}}, \frac{Q_{0-\lambda 1}}{Q_{0-\infty}}, \frac{H_{\lambda 2-\infty}}{H_{0-\infty}}, \frac{Q_{\lambda 2-\infty}}{Q_{0-\infty}}$

These scales give the fraction of blackbody power (or photon rate) emittance falling in the indicated wavelength interval. For wavelengths read from the λ_1 scale, the ratios are

$$\frac{H_{0-\lambda 1}}{H_{0-\infty}} = \frac{\int_0^{\lambda 1} H_\lambda \, d\lambda}{\int_0^{\infty} H_\lambda \, d\lambda}$$

$$= \frac{15}{\pi^4} \sum_{n=1}^{\infty} \frac{e^{-nu}}{n^4} (n^3 u^3 + 3n^2 u^2 + 6nu + 6)$$

$$\frac{Q_{0-\lambda 1}}{Q_{0-\infty}} = \frac{\int_0^{\lambda 1} Q_\lambda \, d\lambda}{\int_0^{\infty} Q_\lambda \, d\lambda}$$

$$= \frac{1}{2.404117} \sum_{n=1}^{\infty} \frac{e^{-nu}}{n^3} (n^2 u^2 + 2nu + 2)$$

(dimensionless)

where $u = \dfrac{hc}{\lambda kT}$.

For convenience, the other integrated quantities are taken from λ_2 to ∞:

$$\frac{H_{\lambda 2-\infty}}{H_{0-\infty}} = \frac{\int_{\lambda 2}^{\infty} H_\lambda \, d\lambda}{\int_0^{\infty} H_\lambda \, d\lambda} = 1 - \frac{\int_0^{\lambda 2} H_\lambda \, d\lambda}{\int_0^{\infty} H_\lambda \, d\lambda}$$

$$\frac{Q_{\lambda 2-\infty}}{Q_{0-\infty}} = \frac{\int_{\lambda 2}^{\infty} Q_\lambda \, d\lambda}{\int_0^{\infty} Q_\lambda \, d\lambda} = 1 - \frac{\int_0^{\lambda 2} Q_\lambda \, d\lambda}{\int_0^{\infty} Q_\lambda \, d\lambda}$$

(dimensionless)

$V_n/\sqrt{R\Delta f}$

This scale gives RMS Johnson noise potential per root ohm-hertz,

$$\frac{V_n}{\sqrt{R\Delta f}} = \sqrt{4kT} \qquad [V/\sqrt{hz\text{-}\Omega}]$$

$E_{\lambda m}$

This scale gives the energy of a photon having wavelength λ_m (at the maximum of H_λ) emitted at temperature T.

$$E_{\lambda m} = (4.965114)kT \qquad \text{ev}$$

PROBLEM SOLVING WITH THE RADIATION SLIDERULE**

The Stock Scales

Quantities which are functions of T alone, $H_{0-\infty}$, $Q_{0-\infty}$, λ_m, $H_{\lambda m}$, $Q_{\lambda m}$, $V_n/\sqrt{R\Delta f}$, $E_{\lambda m}$, can be read directly from the appropriate stock scales when the hairline is set to the desired temperature.

EXAMPLE: Set the hairline to 1000°K on the T scale. Read directly beneath it

$H_{0-\infty} = 5.7$ W/cm^2

$H_{\lambda m} = 1.3$ W/cm^2-μm

$V_n/\sqrt{R\Delta f} = 2.34 \times 10^{-10}$ $V/\sqrt{hz\text{-}\Omega}$

$\lambda_m = 2.9$ μm on the λ_1 scale

from the ENERGY side of the stock, and the photon quantities

$Q_{0-\infty} = 1.52 \times 10^{20}$ photons/sec-cm^2

$Q_{\lambda m} = 2.1 \times 10^{19}$ photons/sec-cm^2-μm

$E_{\lambda m} = .427$ ev

$\lambda_m = 3.67$ μm on the λ_1 scale

from the PHOTONS side of the stock.

**Powers of ten are denoted in Feynman notation on this rule; e.g., 4E − 8 is equal to 4 x 10^{-8}.

The Slide Scales

Quantities which are functions of both wavelength and temperature, $H_{\lambda 1}/H_{\lambda m}$, $H_{\lambda 2}/H_{\lambda m}$, $Q_{\lambda 1}/Q_{\lambda m}$, $Q_{\lambda 2}/Q_{\lambda m}$, $H_{0-\lambda 1}/H_{0-\infty}$, $H_{\lambda 2-\infty}/H_{0-\infty}$, $Q_{0-\lambda 1}/Q_{0-\infty}$, $Q_{\lambda 2-\infty}/Q_{0-\infty}$, can be read from the appropriate slide scale when the central TEMPERATURE arrow on the slide is placed below the desired temperature, and the hairline is placed over the desired wavelength on the λ_1 or λ_2 scale.

EXAMPLE: Move the slide until the TEMPERATURE arrow is directly below 1000°K on the T scale. Set the hairline over 2 μm on the λ_1 (ENERGY side) scale, and read beneath it

$$H_{\lambda 1}/H_{\lambda m} = .68$$

$$H_{0-\lambda 1}/H_{0-\infty} = 6.7 \times 10^{-2}$$

for a blackbody at the given wavelength and temperature.

Turn the rule over to the PHOTONS side, reset the hairline to 2 μm on the λ_1 scale, and read beneath it

$$Q_{\lambda 1}/Q_{\lambda m} = .42$$

$$Q_{0-\lambda 1}/Q_{0-\infty} = 2.1 \times 10^{-2}.$$

Computing Absolute Bandpass Quantities

It is possible to compute various absolute quantities for a given wavelength interval by means of the relations

$$H_{\lambda 1} = \left(\frac{H_{\lambda 1}}{H_{\lambda m}}\right) \cdot H_{\lambda m} \qquad H_{\lambda 2} = \left(\frac{H_{\lambda 2}}{H_{\lambda m}}\right) \cdot H_{\lambda m}$$

$$Q_{\lambda 1} = \left(\frac{Q_{\lambda 1}}{Q_{\lambda m}}\right) \cdot Q_{\lambda m} \qquad Q_{\lambda 2} = \left(\frac{Q_{\lambda 2}}{Q_{\lambda m}}\right) \cdot Q_{\lambda m}$$

and

$$\int_{\lambda a}^{\lambda b} H_\lambda \, d\lambda = \left(\frac{H_{0-\lambda b}}{H_{0-\infty}} - \frac{H_{0-\lambda a}}{H_{0-\infty}}\right) \cdot H_{0-\infty}$$

$$\int_{\lambda a}^{\lambda b} Q_\lambda \, d\lambda = \left(\frac{Q_{0-\lambda b}}{Q_{0-\infty}} - \frac{Q_{0-\lambda a}}{Q_{0-\infty}}\right) \cdot Q_{0-\infty}$$

for long wavelength intervals. The differential forms

$$H_\lambda \Delta\lambda$$

$$Q_\lambda \Delta\lambda$$

may be used for small wavelength intervals. The four multiplier scales, $M(H_{\lambda m})$, $M(H_{0-\infty})$, $M(Q_{\lambda m})$, $M(Q_{0-\infty})$, have been included to expedite the required multiplications.

EXAMPLE: Compute the value of H_λ associated with temperature $T = 1500°C$ and wavelength $\lambda = 8.5\ \mu m$.

Move the slide until the TEMPERATURE arrow is directly beneath 1500°C on the t_c scale. Then set the hairline over 8.5 μm on the λ_1 scale and read the value of $H_\lambda/H_{\lambda m}$, 2.4×10^{-2}, directly beneath it on the $H_{\lambda 1}/H_{\lambda m}$ scale. Transfer this value to the $M(H_{\lambda m})$ multiplier scale by resetting the hairline, and read

$$H_\lambda = .54\ W/cm^2\text{-}\mu m$$

beneath it on the $H_{\lambda m}$ scale.

EXAMPLE: Compute $H_{0-\lambda}$ for a temperature of 350°F and wavelength of 20 μm.

First compute the value of

$$\frac{H_{0-\lambda}}{H_{0-\infty}} = .89$$

as before. Transfer this value to the $M(H_{0-\infty})$ scale by resetting the hairline; read beneath it

$$H_{0-\lambda 1} = .21\ W/cm^2$$

on the $H_{0-\infty}$ scale.

Extending the Range of a Scale

The stock scales may be used with higher or lower values of temperature than those represented on the rule. Simply multiply the desired (absolute) temperature by 10 raised to a convenient power, so that the new temperature appears on the T scale. Solve the problem using this new value of T, then multiply the result by the appropriate factor as listed in Table 1.

Table 1

If T is multiplied by	multiply the value of	by a factor of
10^{-n}	$H_{0-\infty}$	10^{4n}
10^{-n}	$Q_{0-\infty}$	10^{3n}
10^{-n}	$H_{\lambda m}$	10^{5n}
10^{-n}	$Q_{\lambda m}$	10^{4n}
10^{-n}	$V_n/\sqrt{R\Delta f}$	$10^{n/2}$
10^{-n}	$E_{\lambda m}$	10^{n}

NOTE: Without recourse to Table 1, it is possible to deduce the required factor by inspection of the scale itself. For example, if T is reduced by a factor of ten [in going from 1000°K to 100°K, say] the value of $Q_{0-\infty}$ evidently decreases by a factor of 10^3 [1.52×10^{20} to 1.52×10^{17}]. Thus, an additional ten-fold temperature reduction to 10°K would give $Q_{0-\infty} = 1.52 \times 10^{14}$ photons/sec-cm^2.

A similar extension procedure can be used with each of the stock scales.

EXAMPLE: Find $Q_{0-\infty}$ for a blackbody at a temperature of T = 20,000°K. Using the $Q_{0-\infty}$ scale, solve the problem for T = 2,000°K (20,000°K x 10^{-1}). The result is 1.22×10^{21} photons/sec-cm^2. Now multiply this number by a factor of $10^{3n} = 10^3$ to give

$$Q_{0-\infty} = 1.22 \times 10^{24} \text{ photons/sec-cm}^2.$$

The slide scales can also be used over an extended range of temperature and wavelength. Select new, convenient values of λ and T such that the product λT is the same as for the original problem. The result obtained in this way will be correct without modification.

EXAMPLE: Find $H_\lambda/H_{\lambda m}$ for T = 15,000°K and λ = .25 μm. In this case, the product λT will be unchanged if the problem is solved for T = 1,500°K and λ = 2.5 μm. Using the $H_{\lambda 1}/H_{\lambda m}$ and T scales, the result is

$$\frac{H_\lambda}{H_{\lambda m}} = .86$$

for the desired temperature and wavelength.

NOTE: If absolute quantities are subsequently to be derived by means of the slide multiplier scales, it is necessary to modify the results obtained according to Table 1.

Sample Problems

(cf. appendix for more detailed solutions)

1. How much radiant power is emitted by a 1.0 square cm. Piece of firebrick at 1,000°C? The total emissivity of firebrick at this temperature is .75.

Solution:

$$P = \epsilon H_{0-\infty}$$
$$= (.75)(15) \text{ W/cm}^2$$
$$= 11 \text{ W/cm}^2$$

using the t_c, $H_{0-\infty}$, and $M(H_{0-\infty})$ scales.

2. What is the RMS Johnson noise potential developed across a 10,000 Ω resistor at a temperature of 175°F in a 1-hz bandwidth?

Solution:

$$V_n = \left(\frac{V_n}{\sqrt{R\Delta f}}\right) \cdot \sqrt{R\Delta f} \qquad \text{for } 175°\text{F}$$

$$V_n = (1.39 \times 10^{-10}) \cdot \frac{V}{\sqrt{\text{hz-}\Omega}} \cdot \sqrt{10{,}000\Omega \cdot 1 \text{ hz}}$$

$$= 1.39 \times 10^{-8} \text{ V}$$

using the t_f and $V_n/\sqrt{R\Delta f}$ scales.

3. How much radiant power is emitted by 1.0 square centimeter of a tungsten rod at a temperature of 2,800°K in the wavelength interval $.7 \leqslant \lambda \leqslant .75$ μm? The emissivity of tungsten in this interval is .42.

Solution:

$$\Delta H = \epsilon \int_{\lambda a}^{\lambda b} H_\lambda d\lambda \qquad \text{for } T = 2{,}800°\text{K}$$

$$= (.42) \int_{.7\,\mu m}^{.75\,\mu m} H\, d\lambda$$

$$= .42 \left[\int_0^{.7\,\mu m} H_\lambda d\lambda - \int_0^{.75\,\mu m} H_\lambda d\lambda \right]$$

$$= .42\left(\frac{H_{0-.75\mu m}}{H_{0-\infty}} - \frac{H_{0-.7\mu m}}{H_{0-\infty}}\right) \cdot H_{0-\infty}$$

$$= .42(.083 - .060) \cdot H_{0-\infty}$$

$$= .42(.023)H_{0-\infty}$$

$$= (.42)8.0\text{-W}$$

$$= 3.4\ W$$

using the T, λ_1, $H_{0-\infty}$, $M(H_{0-\infty})$, $H_{0-\infty}$, C, and D scales.

4. What is the photon count from a 1.0 cm^2 blackbody at 3,000°C in the interval $15{,}000 \leqslant \nu \leqslant 25{,}000\ cm^{-1}$?

Solution:

$$\Delta Q = \int_{\nu\,=\,15{,}000}^{\nu\,=\,25{,}000\ cm^{-1}} Q_\lambda\, d\lambda \qquad \text{at } 3{,}000°C$$

$$= \left(\frac{Q_{0-15000\ cm^{-1}}}{Q_{0-\infty}} - \frac{Q_{0-25000\ cm^{-1}}}{Q_{0-\infty}}\right) \cdot Q_{0-\infty}$$

$$= (.033 - .001) \cdot Q_{0-\infty}$$

$$= .032Q_{0-\infty}$$

$$= 1.7 \times 10^{20} \text{ photons/sec}$$

using the t_c, ν_1, $Q_{0-\lambda 1}$, $M(Q_{0-\infty})$, and $Q_{0-\infty}$ scales.

5. How much total radiant power is emitted by a 1.0 square cm. blackbody at temperature T = 45°K?

Solution:

$$H = H_{0-\infty}$$

$$= .23 \times 10^{-4}\ W$$

$$= 2.3 \times 10^{-5}\ W$$

using the T and $H_{0-\infty}$ scales with Table 1.

6. Find the total radiant power emitted by a 6,000°K blackbody in a 100Å bandwidth around .35 μm.

Solution:

$$\Delta H = H_\lambda \Delta\lambda$$

$$= \left(\frac{H_\lambda}{H_{\lambda m}}\right) \cdot H_{\lambda m}\Delta\lambda$$

$$= .75H_{\lambda m}\Delta\lambda$$

$$= 7.5 \times 10^3\ W/cm^2\text{-}\mu m \times 100 \times 10^{-4}\ \mu m$$

$$= 75\ W/cm^2$$

using the T, λ_1, $H_{\lambda 1}/H_{\lambda m}$, $M(H_{\lambda m})$ and $H_{\lambda m}$ scales.

7. How much radiant power is received from a 4.0 cm^2 blackbody source at 2,700°K if the blackbody is directly in front of the receiver at a distance of 100 centimeters?

Solution:

$$H = \frac{S_\beta}{\pi d^2} \cdot H_{0-\infty}$$

where: d = distance between viewer and source
S_β = radiating blackbody area

$$H = \frac{4.0\ cm^2 \times 3.0 \times 10^2\ W/cm^2}{3.14 \times (100)^2\ cm^2}$$

$$H = 3.8 \times 10^{-2}\ W/cm^2 \text{ at the receiver}$$

using the T, $H_{0-\infty}$, C, and D scales.

APPENDIX

Sample Problem 1: Set the hairline to 1,000°C on the t_c scale, and read the value 15 W/cm^2 on the $H_{0-\infty}$ scale. To multiply this number by the emissivity, .75, the $M(H_{0-\infty})$ multiplier scale may be used: move the slide until the TEMPERATURE arrow is on 1,000°C. Then set the hairline over .75 on the $M(H_{0-\infty})$ scale, and read the required result, 11 W/cm^2, on the $H_{0-\infty}$ scale.

Sample Problem 2: Set the hairline to the temperature, 175°F on the t_f scale. Read the value of $V_n/\sqrt{R\Delta f}$, 1.39×10^{-10} $V/\sqrt{hz\text{-}\Omega}$, and multiply this by the value of $\sqrt{R\Delta f} = \sqrt{10{,}000\Omega.1hz} = 100\sqrt{hz\text{-}\Omega}$. The result is $V_n = 1.39 \times 10^{-8}$V. For more difficult numerical values, the square root may be found by using the T and D scales: the D scale will read-out directly the square root of the number under the hairline on the T scale. Multiplication can then be carried out with the C and D scales.

Sample Problem 3: Set the TEMPERATURE arrow to 2,800°K on the T scale, and move the hairline to .75 μm on the λ_1 scale. Read the value of $H_{0\text{-}\lambda 1}/H_{0\text{-}\infty}$, .083. Now, move the hairline to .7 μm and read the value of $H_{0\text{-}\lambda 1}/H_{0\text{-}\infty}$ for this wavelength .060. The difference of these two values, .083 – .060 = .023 must be multiplied by $H_{0\text{-}\infty}$; set the hairline over .023 on the $M(H_{0\text{-}\infty})$ scale and read the value 8.0 W from the $H_{0\text{-}\infty}$ scale. Now use the C and D scales to multiply this number by .42, the emissivity. The result is 3.4 W.

Sample Problem 4: Move the TEMPERATURE arrow to read 3,000°C on the t_c scale, and set the hairline over 15,000 cm^{-1} on the V_1 scale. Read the value of $Q_{0\text{-}\lambda 1}/Q_{0\text{-}\infty}$, .033. Reset the hairline to 25,000 cm^{-1} and read the value of $Q_{0\text{-}\lambda 1}/Q_{0\text{-}\infty}$ for this frequency, .001. Compute the difference of these two values, .033 – .001 = .032 and set the hairline to this number on the $M(Q_{0\text{-}\infty})$ scale. Read the required result, 1.7×10^{20} photons/sec, from the $Q_{0\text{-}\infty}$ scale.

Sample Problem 5: Since the temperature of interest, 45°K, is below the range of the T scale, multiply it by 10 and set the hairline to the new temperature, 450°K, on the T scale. Read the value .23 W on the $H_{0\text{-}\infty}$ scale. Since the value of T was multiplied by $10^{-n} = 10$, $n = -1$ here, and the value .23 W must be multiplied by a factor of $10^{4n} = 10^{-4}$ to give the correct result for T = 45°K. It is

$$H_{0\text{-}\infty} = .23 \times 10^{-4} \text{ W}$$
$$= 2.3 \times 10^{5} \text{ W}$$

Sample Problem 6: For this small wavelength interval, the differential form

$$\int_{\lambda a}^{\lambda b} H_\lambda d\lambda = H_\lambda(\lambda_a - \lambda_b) = H_\lambda \Delta\lambda$$

is used. Set the TEMPERATURE arrow to 6,000°K on the T scale. Set the hairline to .35 μm on the λ_1 scale, and read the value of $H_{\lambda 1}/H_{\lambda m}$,

.75. Reset the hairline to this number on the $M(H_{\lambda m})$ scale, then read the value of $H_\lambda = 7.5 \times 10^3$ W/cm²-μ from the $H_{\lambda m}$ scale. Multiply this number by $\Delta\lambda = 100$Å $= 100 \times 10^{-4}\mu$m. The result is $\Delta H = 75$ W/cm².

Sample Problem 7: Set the hairline to 2,700°K on the T scale, and read beneath it the value of $H_{0\text{-}\infty}$, 3.0×10^2 W/cm². Now use the C and D scales to multiply this number by

$$\frac{S_\beta}{\pi d^2} = \frac{4.0 \text{ cm}^2}{3.14 \times (100)^2 \text{cm}^2}$$

The result is $H = 3.8 \times 10^{-2}$ W/cm² at the receiver.

References:

H. W. Makowski, "A Slide Rule for Radiation Calculations," REVIEW OF SCIENTIFIC INSTRUMENTS, 20, 876, (1949)

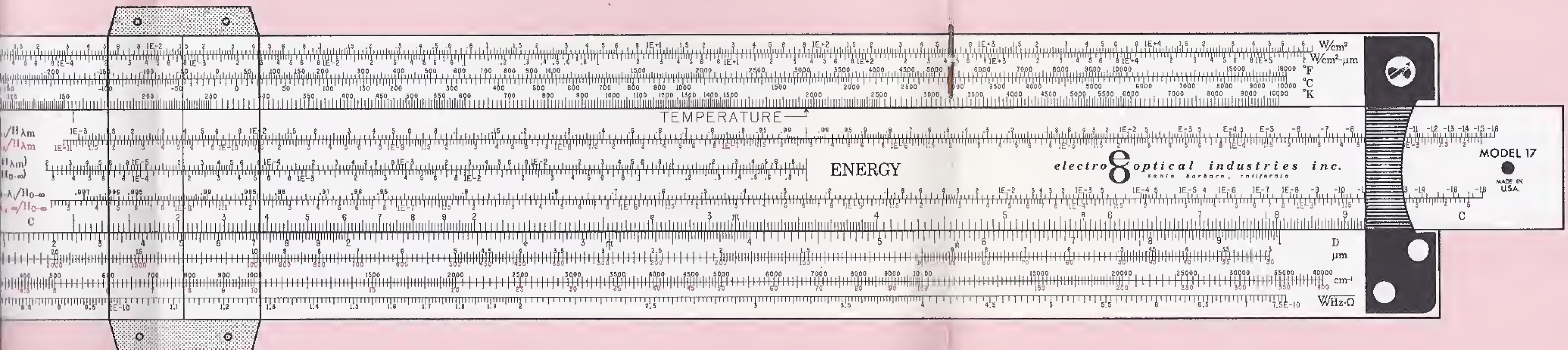
M. Pivovonsky and M. R. Nagel, TABLES OF BLACKBODY RADIATION FUNCTIONS, Macmillan Co., N. Y. (1961)

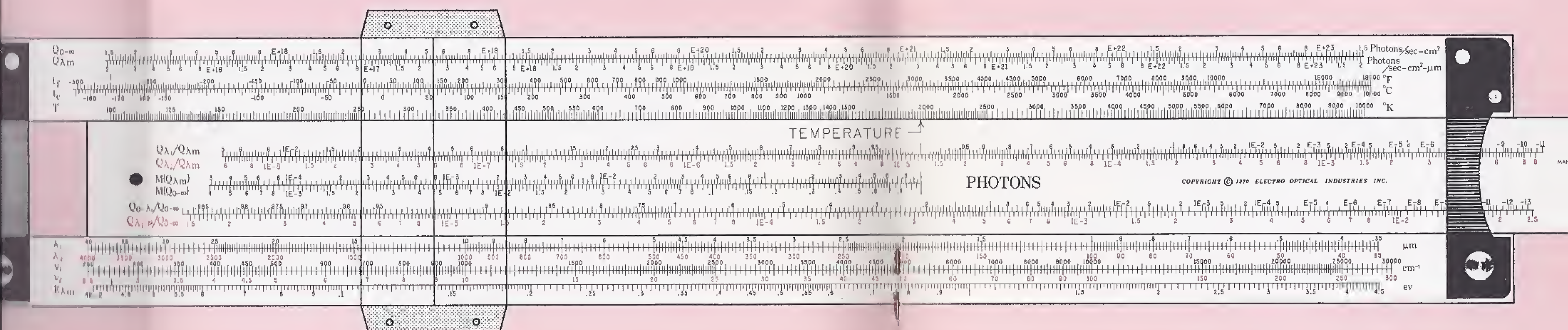
HOW TO ADJUST YOUR SLIDERULE

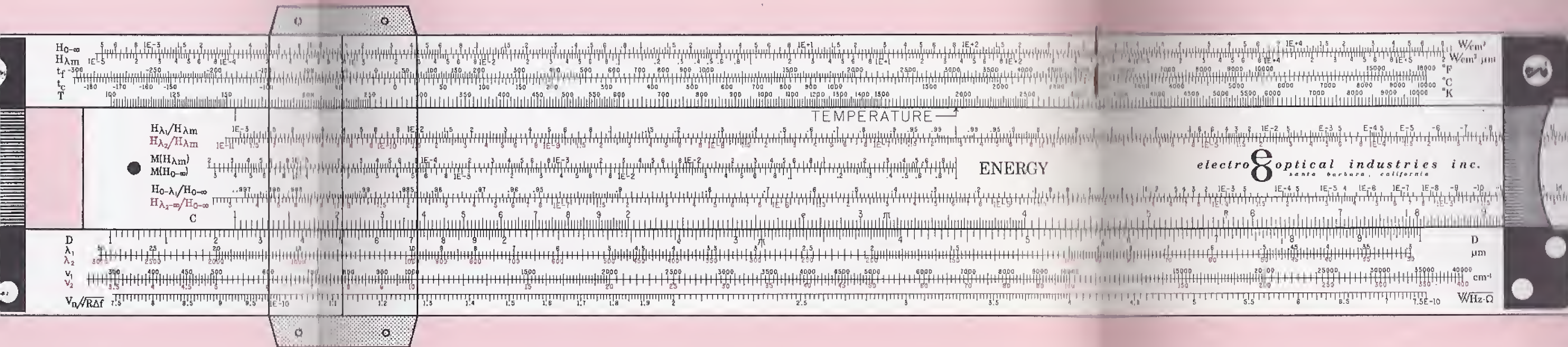
Each rule is accurately adjusted before it leaves the factory. However, handling during shipment, dropping the rule, or a series of jars may loosen the adjusting screws and throw the scales out of alignment. Follow these simple directions for sliderule adjustment.

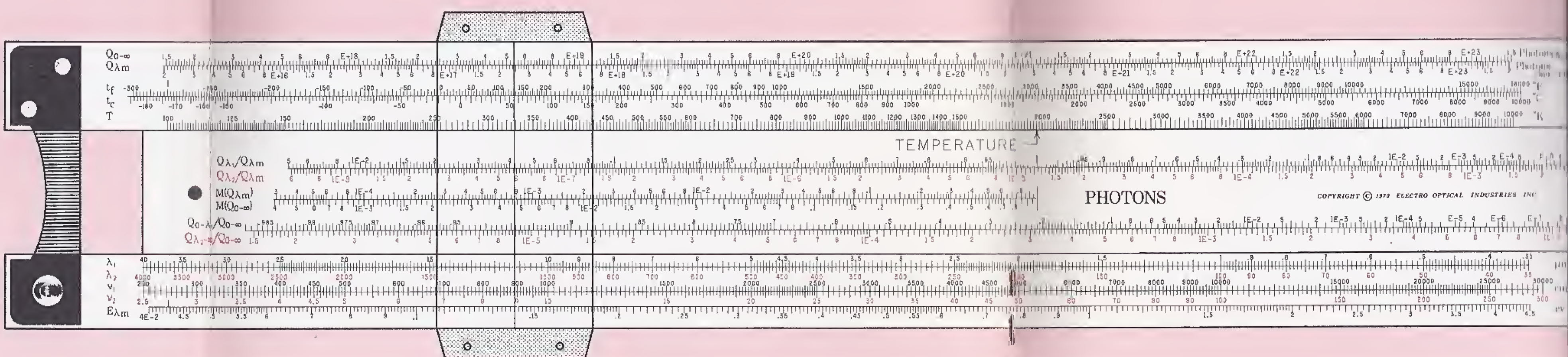
ALIGNMENT OF RULE BODY

1. Position your slide rule so that the adjusting screws in the two end-plates are up and away from you.
2. Loosen the two end-plate screws to achieve slight flexibility in the rule.
3. Position the slider (or center part of the rule so that its left index is aligned with the index on the fixed stator (at the bottom of the rule).
4. Keeping the slider aligned, position the movable stator (at the top of the rule) so that its index is aligned with the slider.
5. With the thumb and forefinger, apply slight pressure to the left side of the rule, and tighten the screw. (Leave a small gap between the slider and stators to achieve smooth rule movement: approximately .003".)
6. Apply slight pressure to the right side of the rule and tighten that adjusting screw – again leaving a small gap.


TEMPERATURE
ENERGY
electro optical industries inc.
santa barbara, california
MODEL 17
MADE IN U.S.A.
W/cm²
W/cm²-µm
°F
°C
°K
C
D
µm
cm⁻¹
W/Hz-Ω


TEMPERATURE
PHOTONS
COPYRIGHT © 1970 ELECTRO OPTICAL INDUSTRIES INC.
Photons/sec-cm²
Photons/sec-cm²-µm
°F
°C
°K
µm
cm⁻¹
ev


TEMPERATURE
ENERGY
electro optical industries inc.
santa barbara, california


TEMPERATURE
PHOTONS
COPYRIGHT © 1970 ELECTRO OPTICAL INDUSTRIES INC